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ART. X. — RECENT PROGRESS IN PHYSICAL SCIENCE.

The New International Platinum-Iridium Standard of Length.

THE International Metric Commission, which met in Paris in October, 1872, had two prominent objects: First, the production of standards of length and of mass with all the refinements of modern science; and second, the organization of a permanent International Bureau of Weights and Measures. The linear standard agreed upon was a bar 4 metres in length, to be made of an alloy of 90 parts platinum and 10 parts iridium, and was to have a cross section represented nearly by the letter X. The bar for this new standard was presented to the French Academy in December last, by Mr. George Matthey of London. The metals used were prepared pure by H. St.-Claire Deville and Debray of Paris. For the bar, five ingots were first made, each composed of 450 ounces of platinum and 55 ounces of iridium, melted together. These were then cut into fragments, which were again thoroughly melted and cast into a single ingot. This ingot was rolled out, cut into strips, and again melted and cast. The new ingot was forged into a bar, then rolled between polished steel cylinders until reduced to nearly the size required, and finally drawn and finished on a planing-machine. As presented, the bar had a length of 410 centimetres, a breadth of 2.1 centimetres, and a thickness of 0.5 centimetre. After annealing, the bar had a density of 21.516. Analysis showed it to be very homogeneous, and to contain 99.33 parts of the required alloy, the remaining 0.67 part being iridium in excess, rhodium, ruthenium, and iron. The production of so satisfactory a bar, considering the difficulty experienced in working the metals of which it is composed, is justly regarded as a great metallurgical triumph. The finishing and graduating of the standard has been intrusted to MM. Brünner of Paris.

Extinction of one Musical Sound by another.

Professor Mayer in a recent paper announces the remarkable discovery that one sound may entirely obliterate another, if it be more intense than this other. His earlier experiments were made with the ticks of a clock and of a watch; when the two were at certain distances from the ear the louder clock-tick entirely extinguished the feebler watch-tick which took place at the same instant. Careful measurement proved that the intensity of the former must be at least three times that of the latter, to produce the effect. Extending his investigations to musical sounds, Professor Mayer observed that pitch had to do with the result, and that on the one side not only may a more intense sound, lower in pitch than another, obliterate it entirely, but that on the other no sound, however intense, can extinguish the sensation of a concurrent sound when the latter is lower in pitch. Some curious phenomena follow from these facts. If, for example, a sentence be read aloud in a given tone of voice, and a c′ organ pipe be at the same time forcibly sounded, it appears as though two persons were simultaneously reading, one with a grave voice, the other with a high pitched one, which is squeaky and nasal. The author makes two important applications of his discovery: First, to orchestral music, in which, as now conducted, the sounds of the violin, and even those of the clarionet are often entirely obliterated by the deeper and more intense sounds of other instruments; thus altering the peculiar expression intended by the composer. It is evident, therefore, that a knowledge of this law of extinction must not only be of the greatest value in future musical composition, but also that it has an important present application by establishing the fact that in directing our existing music the conductor should be placed, not in the midst of his performers, but in the position occupied by an average hearer. The second application is to the determination, by means of the new law, of the relative intensities of sounds, so that the data for producing any desired effect may be accurately obtained.

Experiments with the Radiometer.

The little instrument devised by Mr. Crookes in 1873, and called by him a Light-mill or Radiometer, has continued to excite great interest in scientific circles. It consists of a light frame of four arms, carrying at their extremities four disks or squares, usually of mica, blackened on one side, the whole being supported on a pivot of steel, and enclosed in a glass globe carefully exhausted. Upon exposure to light the vanes rotate, the unblackened side in advance. Mr. Crookes at first supposed the cause of the motion to be the direct impact of light, and in a paper presented to the Royal Society in 1876, he states that the mechanical force of a candle twelve inches distant is .000444 grain, and six inches distant, .001772. The light of the sun was equal in one experiment to that of 10.2 candles six inches off; from which datum he calculates the "pressure of sunshine" to be 2.3 tons on every square mile of the earth's surface. The true cause of the motion was established by Mr. Stoney, who showed that it was due to the reaction between the walls of the globe and the blackened side of the vanes, this reaction being produced by the impact of the molecules of the residual gas, whose velocities are alternately increased and diminished by contact with the warmed and cooled surfaces, respectively. The reaction cannot take place under the atmospheric pressure, since the mean length of free path of any molecule is only one two-hundred-and-fifty-thousandth of an inch, while in a vacuum of one four-millionth of atmospheric pressure the length of this path is sixteen inches. Various experimenters, each in his own way, have abundantly confirmed this theory. On the question whether residual air is necessary, M. Kundt showed that if a delicately suspended disk be suspended in the same globe directly above the vanes, it will be set in rotation in the same direction by the current of air from the vanes. Mr. Crookes proved that when the globe is revolved, of course in complete darkness, so far as the instrument is concerned, the vanes will be carried round by the friction of the residual air. M. Alvergniat, by exhausting the globe at 400° C., obtained so perfect a vacuum that no rotation took place. A small quantity of air being admitted, the apparatus performed as usual. M. Finkener, by a very ingenious method, proved that the rotation increased with the rarefaction up to a maximum, and then decreased, becoming null when the vacuum became nearly perfect. He showed that the maximum effect was obtained in a vacuum in which the pressure was 0.007 millimetre of mercury; and also that the rotation of the vanes was the more rapid the smaller the globe in which they were enclosed. On the question of the reaction between the vanes and the containing vessel, Mr. Schuster floated the globe delicately in water, and observed that when the vanes moved one way the globe revolved slowly in the other. M. Righi obtained the same result by suspending the radiometer by a filament of silk. The torsion was in one direction as the velocity increased, and in the other as it diminished. Reversing the instrument, and again suspending it as before, no amount of light caused a perceptible movement; proving the forces active in the phenomenon to reside entirely within the instrument. Professor Rood proved the reaction by supporting opposite to and on the same arm as one of the two vanes composing the mill, a delicate screen. When light acted on the unscreened vane, reaction took place between this vane and the walls of the vessel, and rotation was the consequence. But when the screened vane received the light, the impact of the retreating molecules was against the screen; which, being on the same support, antagonized the vane, and prevented rotation. While, therefore, the Radiometer does not establish the materiality either of light or heat, yet it is an exceedingly interesting instrument for illustrating the dynamic theory of gases.

Divided Circles on Glass.

Mr. L. M. Rutherfurd of New York has introduced an important improvement into instruments for measuring angles, which bids fair to work a revolution in this class of instruments, and which consists simply in using glass circles for the divisions instead of metal. The circle used by Mr. Rutherfurd is on a spectrometer, and is ten inches in diameter, being carefully graduated to ten minutes of arc. The great advantage of these circles lies in the fact that the lines, being ruled with a diamond point, are of the greatest delicacy, being finer when seen through the reading microscopes than even the spider-lines themselves. From the transparency of the glass, moreover, the illumination may be made as complete as is desired. Hence Mr. Rutherfurd believes that for astronomical purposes a circle fifteen inches in diameter would give greater precision, when read with powerful microscopes, than the largest metallic circles now in use. In the spectrometer referred to, in which the microscopes magnify seventy-five diameters, the probable error of a single reading is considerably less than half a second.

Spectroscopic Measurement of the Sun's Rotation.

The direct proof of change in the wave-length of light by motion of the luminous body to or from the observer, being impossible by reason of the immense velocity of this agent, Professor

Young has successfully made use of the opposite motions of the two limbs of the sun for this purpose. The spectrum used was that of the sixth order, — though the seventh and eighth were also used, — obtained from one of Mr. Rutherfurd's exquisite gratings of 8,640 lines to the inch, the overlapping of the spectra of these high orders being corrected by inserting between the ruled plate and the observing telescope a glass prism of 45°, with its edge perpendicular to the ruled lines, so arranged as to refract upward the superposed colors at any one point, in the order of their refrangibility. With this high dispersion, the difference in the position of the two D lines and of the nickel line between them becomes quite sensible; and by means of micrometers, measurable. Assuming the velocity of light to be 186,600 miles per second, and taking the best determinations of wave-length of the two D lines, Professor Young has calculated that the difference in the velocity of two points on the sun's equator on opposite limbs is 2.84 miles per second, with a probable error of 0.07. This result, which corresponds to a velocity of rotation of 1.42 miles per second, while close enough to the velocity deduced from the time of rotation of the spots, 1.25 miles per second to establish the change in wave-length by motion, is yet too widely different from the latter to allow us to suppose they refer to the same quantity. Hence, Professor Young is inclined to believe that the velocity of the chromosphere, where the absorption is effected which produces the lines measured, is actually greater by 0.17 mile per second than that of the photosphere in which the spots lie; a result by no means improbable.

Protection of Buildings from Lightning.

Professor Maxwell, believing that the ordinary arrangement of lightning-rods is calculated rather for the benefit of the surrounding country, and for the relief of clouds laboring under an accumulation of electricity than for the protection of the building on which the rod is erected, suggests some modifications in the common plan. What is really desired is to prevent the possibility of an electric discharge taking place within a certain region; as, for example, a gunpowder manufactory. Now, no discharge of electricity can take place except between bodies differing greatly in potential; the electricity passing from the body of higher to that of lower charge. If, therefore, it be possible to keep the potential uniform within a certain region, no discharge can take place between bodies within it. This may readily be done by connecting all the bodies in the region by a metallic conductor. In the case of the powder-mill, the building should be enclosed in a network of some good conductor, say a copper wire, No. 4 of the Birmingham wire gauge. This should be carried round the foundation, up each of the corners and gables, and along the ridges. It may be built into the wall to prevent theft, but should be connected to all outside surfaces of metal. If there are water or gas pipes, they should be put in contact with the wire; but if there are none, it is not necessary to facilitate in any way the escape of the electricity into the earth.

The New Elements Gallium and Neptunium.

Two additions have recently been made to the list of chemical elements. The first of these, the metal *Gallium,* — called so from Gallia, — was observed by M. Boisbandran in a zinc blende from the Pyrenees. He recognized it as new by the peculiarities of its spectrum, which consists of two bright lines only, situated in the violet, the more refrangible of which lies beyond even the violet line of potassium. Their wave-lengths are 417 and 403 ten-millionths of a millimetre respectively. The metal itself is grayish-white and lustrous, but tarnishes in moist air. It liquefies at 30.15° C., and may therefore be melted by the heat of the hand. When melted it exhibits the property of suffusion to a remarkable degree, remaining liquid for weeks even at temperatures near zero. In the solid form, which is obtained readily by touching the fused mass with a fragment of solid gallium, the metal is hard and resistant, though it may be cut, and is flexible and malleable. It is not volatile, and has a density of 5.956. Its atomic weight has not yet been fixed, owing to the small quantity thus far prepared; but as it forms a well-defined alum, its chemical relations would seem to ally it to aluminum. The second new element was discovered in the mineral columbite, from Haddam, by M. Hermann. It is called *Neptunium,* and belongs to the group which already contains tantalum, columbium, and ilmenium. Its chemical reactions sharply distinguish it from the other members of the group, as also does its atomic weight, which M. Hermann finds to be 118.